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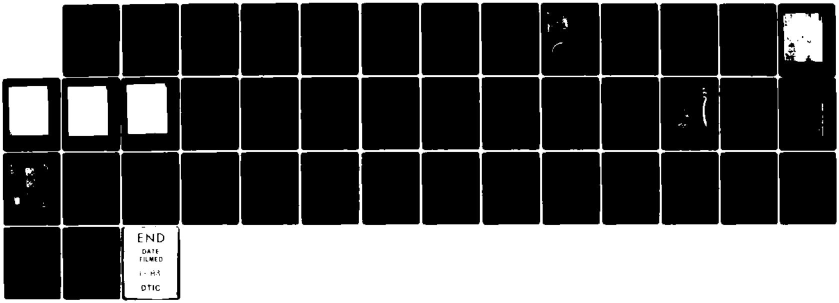

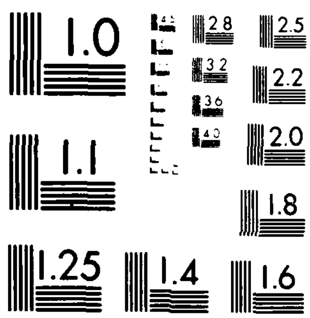

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AD A122269

Operational and Technical Evaluation of the Full Digital Automated Radar Terminal Systems (ARTS) Display (FDAD)

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Final Report

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NOTICE

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16. Abstract

This report discusses the operational and technical evaluation of the Full Digital Automated Radar Terminal Systems (ARTS) Display (FDAD). The FDAD was capable of providing data entry, data display, data refresh, and input/output functions of either ARTS II, ARTS III, or ARTS IIIA computer. Three different cathode-ray tube phosphors, including color, were evaluated. Data were displayed either in a full-digital mode or a time-share mode. During the time-share mode, the display of digital data was time shared with analog radar/beacon target reports. Modifications to software, hardware, and display firmware would be required to make the FDAD's operationally suitable. The technical evaluation conditionally accepts the displays, as tested, and it recommends their use as field displays, provided certain modifications are made.

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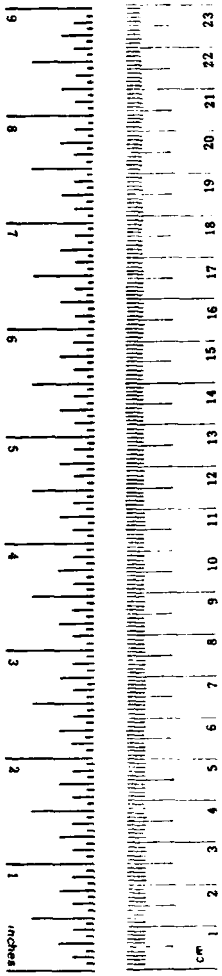
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

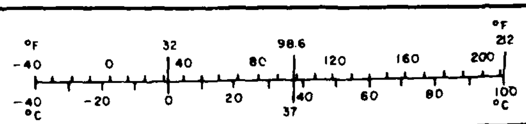
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

The purpose of this project was to determine the suitability of the Full Digital Automated Radar Terminal Systems (ARTS) Display (FDAD) for operational use in air traffic control facilities using ARTS computers.

BACKGROUND.

There have been extensive hardware and software advances in state-of-the-art concepts for terminal air traffic control systems. One new concept is the radar digitizer. It permits data from the primary radar system to be compatible for use with ARTS computers. Radar digitizing and beacon digitizing accomplished at a sensor site make it possible for the digitized data to be transmitted via narrow-band digital techniques on comparatively low-cost telephone lines. Current terminal air traffic control procedures require that radar displays be operated in the time-share display mode. Analog radar/beacon target reports are displayed with digital data.

The success of this concept depends on the use of a synthetic presentation on a full digital display instead of the current presentation which includes broadband. Because of this, a need now exists to modify the currently used ARTS displays to full digital use or to provide a new display subsystem that has a full digital capability. Considering that the current ARTS displays are nearing the end of their 20-year life expectancy, it is obvious that a display replacement program is necessary.

In order to accomplish this in the most expeditious manner, a Federal Aviation Administration (FAA) Engineering Requirement (ER), FAA-ER-D-120-007, was issued by the Systems Research and Development Service in 1979. Subsequently, a contract was awarded to the Magnavox Corporation to develop and fabricate six engineering model displays. This report addresses both the operational and technical evaluation of these displays.

EQUIPMENT DESCRIPTION.

The FDAD, figure 1, consists of the following components mounted in a vertical console: (1) solid-state, programmable, microprocessor-based, control circuitry, (2) solid-state memory and refresh memory, (3) 23-inch cathode-ray tube (CRT), (4) display drive electronics, and (5) alphanumeric keyboard and a track ball slew device for entry of message functions and positional data.

The FDAD is capable of providing the following: (1) data entry and display, (2) input/output interface function with ARTS II, ARTS III, or ARTS IIIA, (3) programmable alphanumeric character size, (4) "quick look," or the observation of data block information from other displays, and (5) internal buffer refresh function.

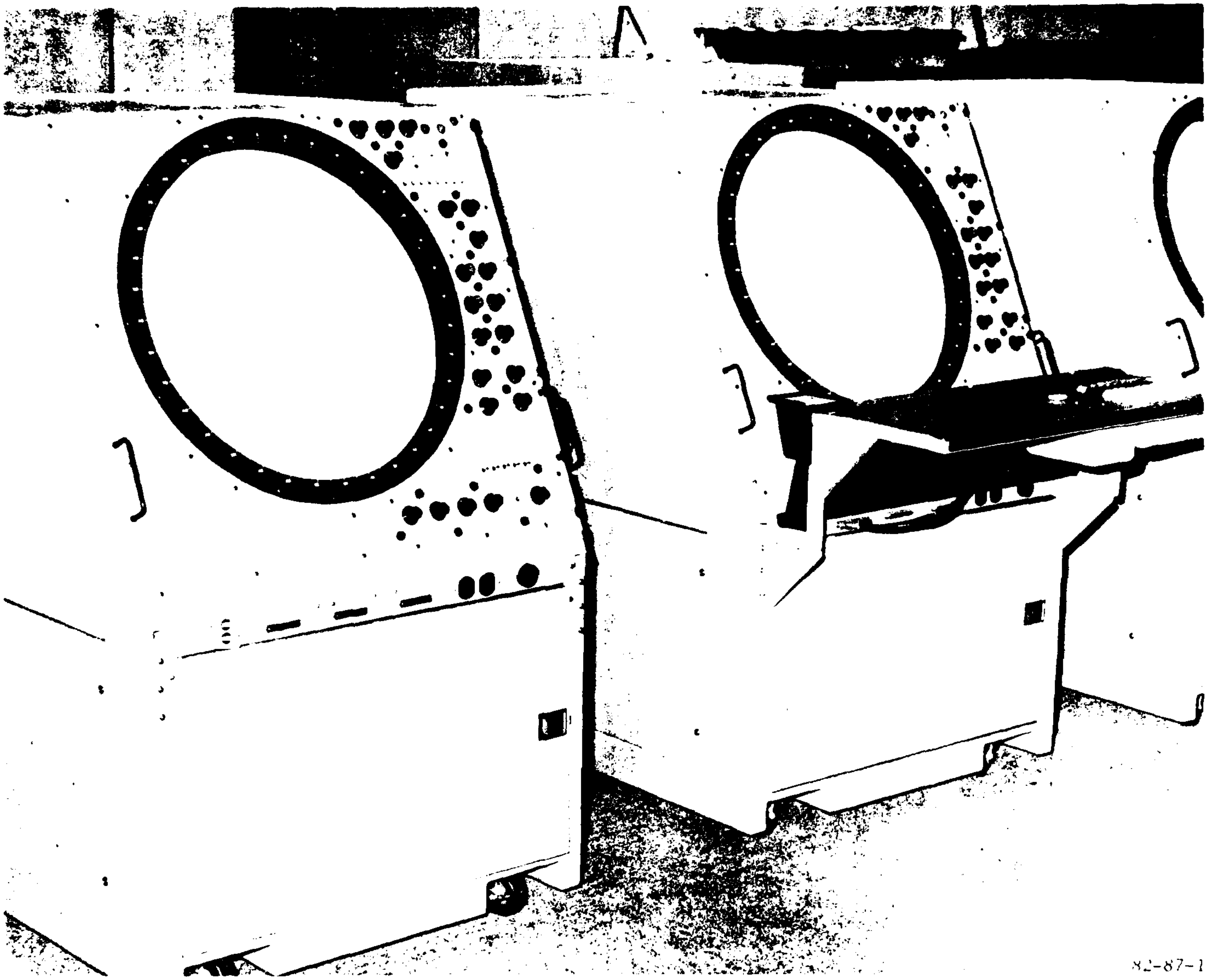

FIGURE 1.   FDAD CONSOLES, FRONT VIEW

The FDAD displays were designed for operation in any of three modes — time-share, digital, or digital color. The mode of operation is determined by CRT phosphor type and internal display microprocessor operation. In the time-share mode, analog/radar/beacon target reports, radar video map, and range marks can be displayed with or without digital data. In the digital mode, digital data are displayed with digitized target reports, and FDAD internally generates maps and range circles.

Five FDAD's were installed and integrated into the Technical Center's Terminal Automation Test Facility (TATF) computer complex. Displays numbered 1 and 2 (Type 1) have a monochromatic CRT with a phosphor mixture of P2, P22B, and P28 to provide long persistence (i.e., slow output decay time) for radar sweep and short persistence for digitally displayed data. Displays numbered 3 and 4 (Type 2) have a monochromatic CRT with a P31 phosphor to provide short persistence and a high brightness efficiency most effective for display of digital data. Display number 6 (Type 3) had a multichromatic CRT with a P49 phosphor which displayed digital data in four colors. (Display number 5 was retained at the factory to test recommended modifications.)

Radar and video map inputs, required for the time-share operation, were obtained from the Atlantic City Approach Control Airport Surveillance Radar Model 4 (ASR-4). Digitized radar input required for digital operation was obtained from the Technical Center's ASR-7 Mode S sensor. Digital maps and range circles were generated by the FDAD's. The operational software versions utilized during the test and evaluation were the All Digital System 2 (ADS 2) program, used for the time-share mode, and the modified version of the ADS 2 program, created for driving the FDAD units in the Change Data Only (CDO) mode.

METHOD OF APPROACH

PART 1: OPERATIONAL EVALUATION.

The Type 1 and Type 2 FDAD's were evaluated in the time-share mode of operation without alphanumerics and in the digital mode of operation with alphanumerics. Due to laboratory configuration and equipment problems, it was not possible for the duration of the evaluation periods to have the FDAD's configured in the time-share mode with alphanumerics. The Type 3 FDAD was not operationally evaluated in the time-share mode, since design requirements did not specify such an operation.

PART 2: TECHNICAL EVALUATION.

The FDAD units are candidate displays meant to be considered in the replacement of the aging ARTS III displays. The following concerns itself with various FDAD operational parameters that were not investigated during the factory acceptance tests. Many of the proposed evaluation tests, originally envisioned in project plan FAA-CT-80-209, were deemed redundant and unnecessary. They included (1) maximum usable brightness and linewidth determination, (2) display positional accuracy determination, (3) phosphor energy output measurement, and (4) chromaticity and illuminance measurement. The "minimum detectable signal measurement" and "effects on displayed color from induced nondestructive color failures" were eliminated since they were irrelevant in comparison to the ARTS III displays. The following tests were conducted: (1) video and deflection amplifier bandwidth determination; (2) radio-frequency interference from electromagnetic radiation; and (3) system power consumption measurement. A summary and analysis of maintenance logs have been added along with observations by users (appendix A).

DATA COLLECTION

PART 1: OPERATIONAL EVALUATION.

The FDAD's were evaluated through the collection of subjective data obtained from questionnaires. The questionnaires were completed after 2-hour periods of FDAD usage by Air Traffic Control Specialists (ATCS's). During the 2-hour evaluation periods, the ATCS's exercised FDAD controls and assessed the resultant display presentation. Numerous keyboard and track-ball entries were made initiating ARTS III data blocks on targets of opportunity.

Data collection was to be conducted in two phases. Phase I utilized 25 ATCS's from the Technical Center and 1 from the Atlantic City Approach Control Facility. Phase 2 planned to utilize radar qualified ATCS's from terminal facilities adjacent to the Technical Center. Phase 2 was not accomplished because of the unavailability of ATCS's due to the controller strike.

PART 2: TECHNICAL EVALUATION.

The data collection for radio-frequency interference measurements and power consumption readings were accomplished in the TATF laboratory. Bandwidth measurements for "X" and "Y" deflection amplifiers and video amplifier were completed in the Display Engineering laboratory. Following is a list of test equipment used:

1. Tektronix Spectrum Analyzer, 1 KHz to 1.8 GHz, Model 7L13 calibration 4-11-81.

2. Interstate Electronics Corporation Function Generator, 11 MHz, Model F55A/RC, calibration unknown.

3. Interstate Electronics Corporation Log-Linear Sweep Generator, 20 MHz, Model F77, calibration unknown.

4. Tektronix Mainframe Oscilloscope, Model 7603, calibration 8-15-78.

5. Tektronix Dual Trace Amplifier, Model 7A18, calibration unknown.

6. Tektronix Delaying Time Base, Model 7B85, calibration unknown.

7. Tektronix P6062B Oscilloscope Probes (2).

8. Amprobe A.C. Wattmeter Recorder, Model AW50, calibration 6-24-74.

RESULTS

PART 1: OPERATIONAL EVALUATION.

A complete compilation of the questionnaires from the data collection is presented in appendix B. Observations made by the test directors are included in the Discussion of Results section of the report. It is from these that the results were obtained. Responses have been divided into two categories: (1) Display Presentation and (2) Display Control Location and Operation.

DISPLAY PRESENTATION. A majority of the responses indicated that:

1. The increased alphanumeric character size in lieu of data blinking during a handoff situation was unsatisfactory.

2. When operating the display in the time-share display mode, the display of radar data on Type 1 displays (figure 2) was satisfactory.

3. When operating the display in the time-share display mode, the display of radar data on Type 2 displays (figure 3) was not acceptable.

4. When operating both the Type 1 and Type 2 displays in the digital display mode, (figures 4 and 5) the display of digital data on both was satisfactory, but the Type 2 display digital presentation was preferred.

5. The assignment of colors used to display data on the Type 3 display was satisfactory.

6. The computer controlled brightness level of all colors on the Type 3 display was satisfactory.

7. No fatigue was encountered during the observation of the Type 3 display.

DISPLAY CONTROL LOCATION AND OPERATION. A majority of the responses indicated that:

1. The operation and location of all display controls were satisfactory.

2. The location of the alphanumerics keyboard, track-ball, and writing shelf was satisfactory.

3. The operation of the track-ball was satisfactory.

4. No control interaction was observed between any of the digital data brightness controls.

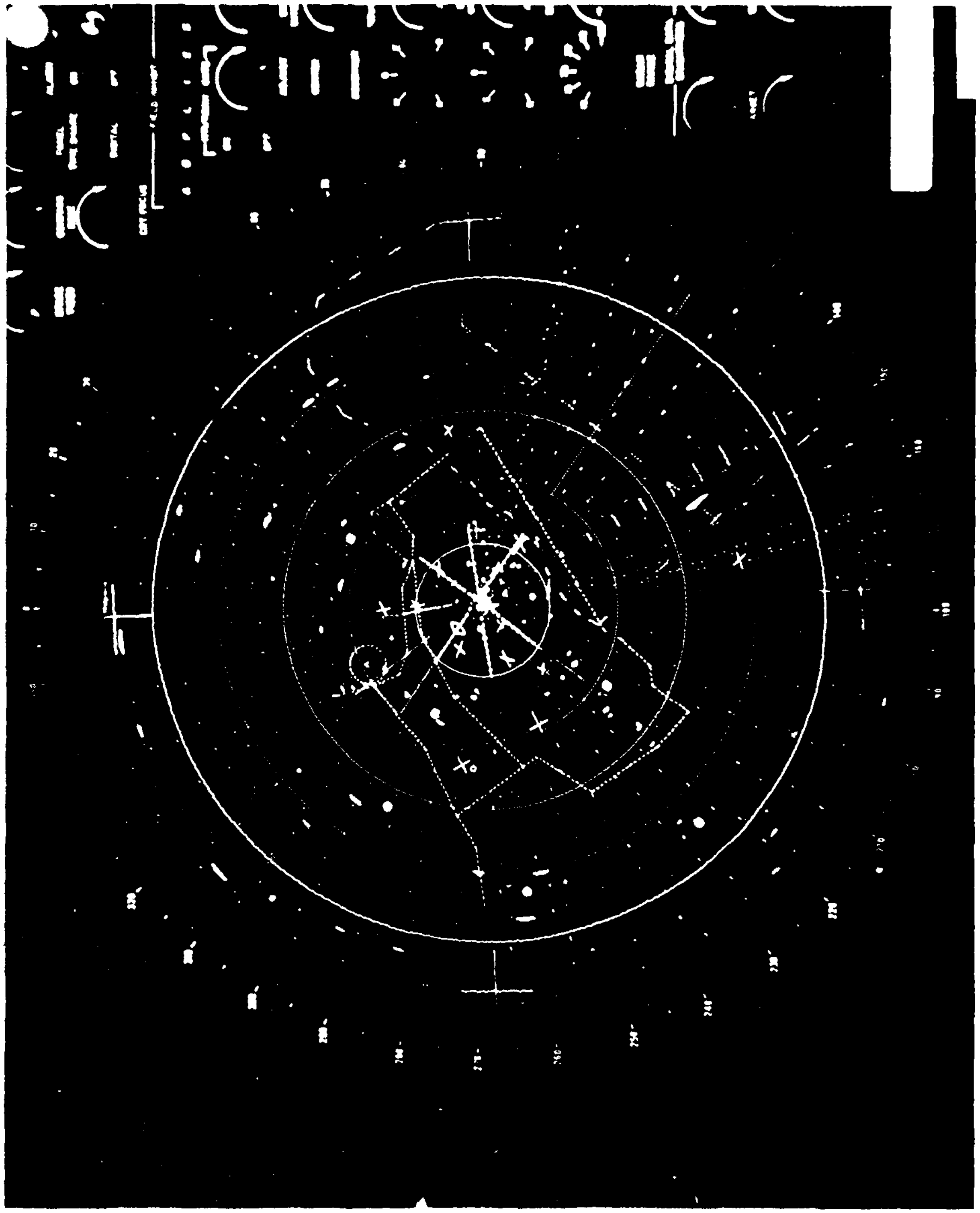

FIGURE 2. TYPE I DISPLAY (TIME-SHARE MODE)

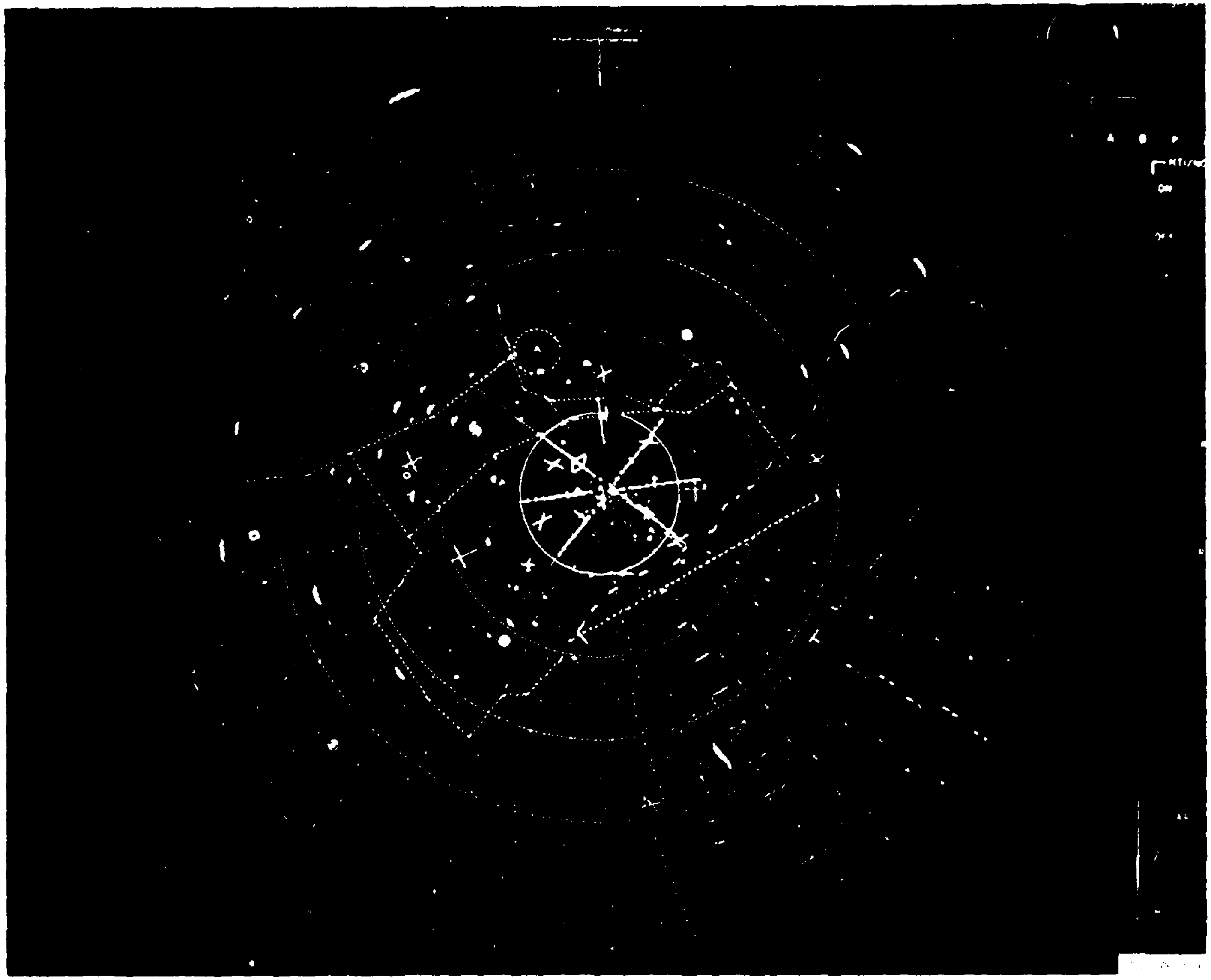

FIGURE 3. TYPE 2 DISPLAY (TIME-SHARE MODE)

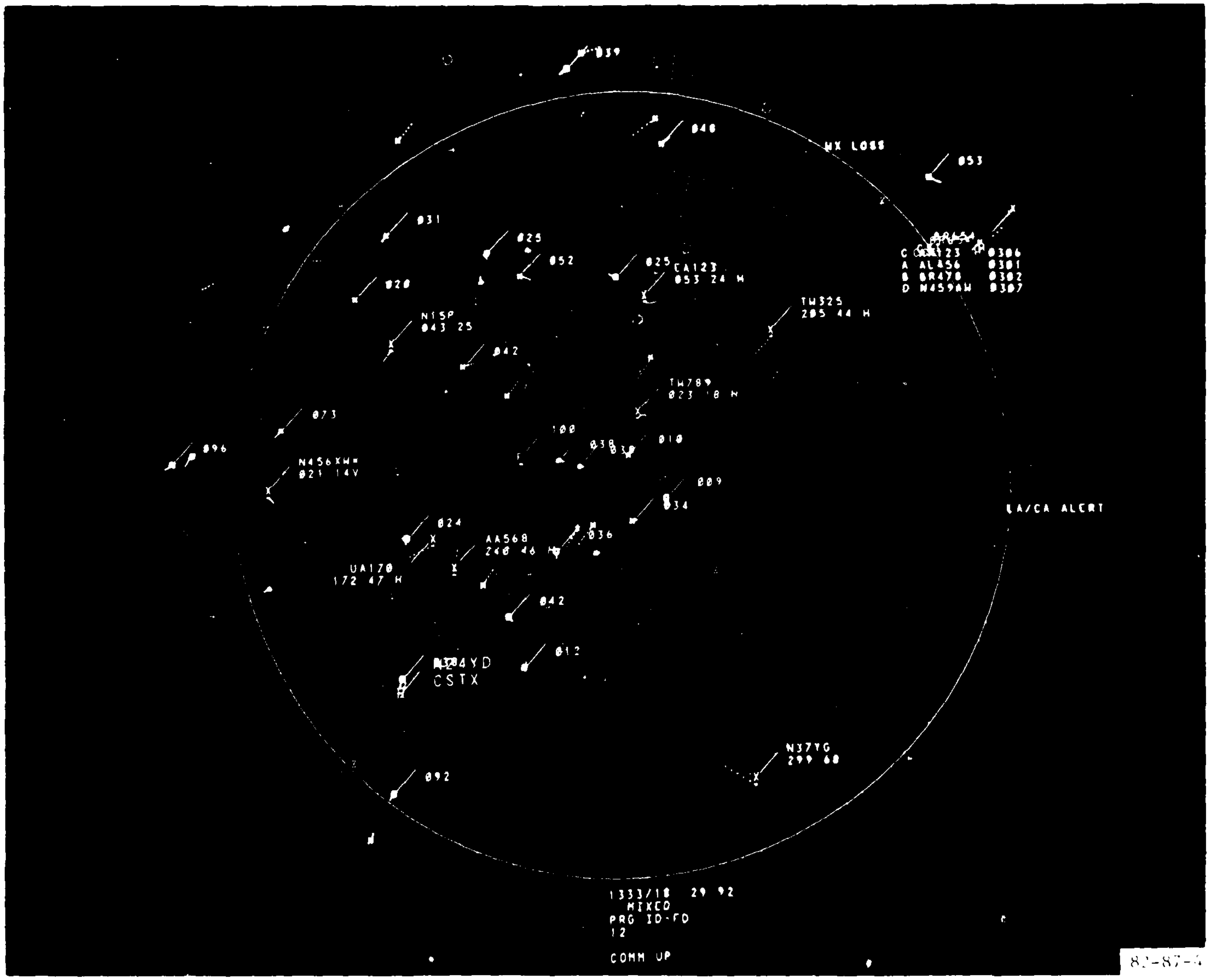

FIGURE 4. TYPE 1 DISPLAY (DIGITAL MODE)

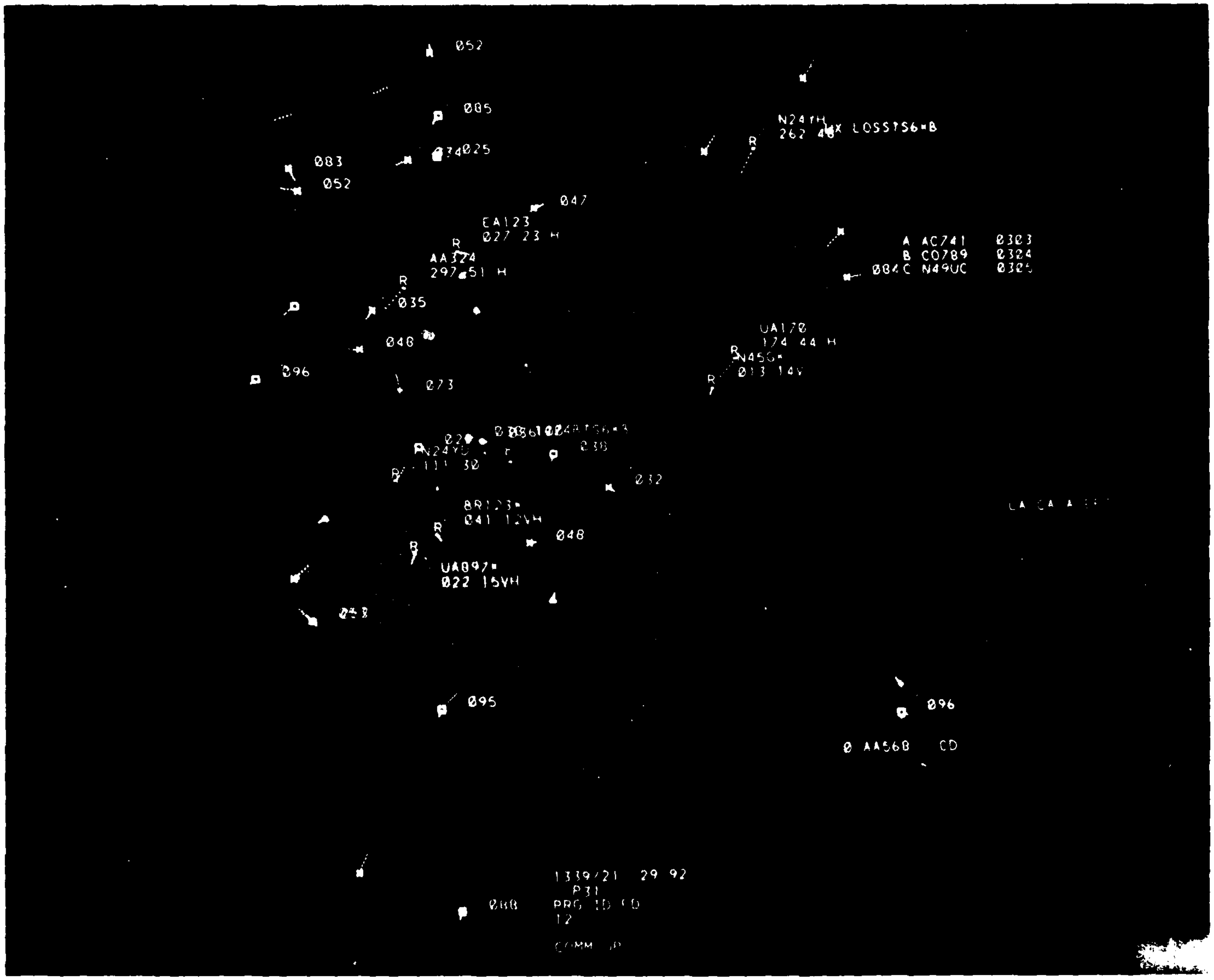

FIGURE 5. TYPE 2 DISPLAY (DIGITAL MODE)

PART 2: TECHNICAL EVALUATION.

1. The FDAD displays consume, on the average, 22 percent less power than the ARTS III displays.

2. The radio-frequency *interference spectrum* is considerably stronger from the FDAD units than from the ARTS III consoles.

3. Deflection amplifier bandwidth measurements indicate that 8 out of 10 amplifiers fail to meet their rated performance capability of 3.75 megahertz.

4. Video amplifier bandwidth measurements show that the designed rating of 20 megahertz has been met in all five displays.

5. Maintenance logs indicate a definite problem with the wire-wrap boards and connectors used for circuit construction.

6. The low-voltage power supply is easily susceptible to failure when subjected to adverse conditions.

7. During range mark generation, there is a summation of ground clutter to range mark intensity producing a noticeable brightening over the ground area.

8. Range marks become serrated during ARTS III normal and radar data mode.

DISCUSSION OF RESULTS

PART 1: OPERATIONAL EVALUATION.

In the compilation of the controller questionnaires used to evaluate the FDAD, the responses to 30 of the 53 questions reflected a decisive majority (80 percent or better). Questions that received responses less than a decisive majority were grouped into the same categories as the results.

Responses pertaining to the display presentation category indicated the following:

1. When operating the Type 1 and Type 2 displays in the time-share mode, the displayed radar targets on the Type 2 displays were unsatisfactory. The Type 2 display is equipped with a CRT with P31 phosphor. The P31 phosphor, by design intent, is a low retention phosphor. It was not intended for use in the time-share mode of display operation. Therefore, by design, the FDAD's with CRT's having P31 phosphor would be unsuitable for use in present-day air traffic control facilities when operated in the time-share mode.

2. Although the displayed data, both in the time-share and digital display modes, were deemed satisfactory, several discrepancies were observed during the operational evaluation. Those not corrected by either display adjustment, display hardware, or firmware modifications are as follows: (a) An excessive number of display reinitializations to a quiescent state when the display was operated in the digital display mode. All displayed data were erased and reinitialized when this occurred. This reinitialization cannot be attributed individually to

either the FDAD, TATF equipment, or the ADS 2/FDAD computer program. (b) Change of intensity of alphanumerics (flicker). This, like the previous discrepancy, cannot be attributed individually to either the FDAD, TATF equipment, or the ADS 2/FDAD computer program. (c) Distortion of data block leaders and lines forming the heavy weather contours. (d) An unequal range mark intensity at reduced display ranges during clutter breakthrough when operating the displays in the time-share mode. (e) Distortion of range marks when operating the display in the time-share mode with alphanumerics displayed. This discrepancy could be eliminated by placing either the time compresssor or alphanumeric switches in the "ON/OFF" position.

Responses pertaining to the display control location and operation category indicated the following:

1. The location of the display controls below the level of the writing shelf, although deemed satisfactory, could be greatly improved. Comments indicated that all of these display controls should be relocated.

2. The location of the writing shelf and data entry devices on the shelf, although deemed satisfactory, could be greatly improved. It was observed that the location of the keyboard and track-ball was not conducive to use of the writing shelf, and when adjusting the display controls below the shelf level, one had to reach over the keyboard. This could add extraneous characters to the message validity display area. Depression of the "CLEAR" key was required before entering keyboard messages.

3. The operation of the digital data brightness controls, although deemed satisfactory, could be greatly improved. Two of the controls were mislabeled. The control labeled "TARGET," actually affected the intensity of the alphanumerics. The control labeled "OTHER," actually affected the intensity of the target position symbol. Responses to the question pertaining to the suitability of the "MAP/CIRCLE" control indicated that the control operation was satisfactory, but not optimum. Comments accompanying the responses indicated that ATCS's preferred a separate brightness control for both the digital map and range circles.

4. While track-ball movement was deemed satisfactory, it was observed that the track-ball movement was not the same when operating the display in the ARTS II Normal mode, as compared with track-ball movement when the display was placed in the ARTS III Change Data Only (digital) mode. More rotation of the track-ball was required to move the same distance when in the ARTS III Normal mode.

PART 2: TECHNICAL EVALUATION.

RADIO-FREQUENCY INTERFERENCE MEASUREMENT. Radio-frequency interference (RFI) measurements were tabulated over four areas of the display consoles: CRT surface, side control panel, front control panel, and rear input power connections. Other areas on the consoles were also checked, but they proved to be insignificant and too similar to the aforementioned locations. The radio-frequency electromagnetic radiation was monitored between 1 and 100 megahertz on a -30 dBm scale (1 microwatt). The greatest signal received was from the CRT surface at around 8 microwatts and 6 megahertz. Another significant signal occurred at approximately 6.5 microwatts and 18 megahertz. All FDAD units had similar spectral distribution curves with the greatest similarity coming between those with identical CRT phosphors. (See figures 6, 7, and 8.) The RFI power level from the distribution curves drops to half of its value for every 4 inches away from the measured area. Therefore, a power reading of 8 microwatts would become 4 microwatts and 2 microwatts at 4 inches and 8 inches, respectively. A radio-frequency spectrum scan was also taken from two ARTS III displays for comparison. (See figures 9 and 10 versus 6, 7, and 8.) As can be seen from the test results, there is a great difference between the CRT surface spectrums of the new FDAD units and the existing ARTS III displays. The other areas are basically the same. Because of the relatively small RFI signal being emitted from the FDAD displays (8 microwatts) and the quickness with which it drops off, RFI will not be detrimental to peripheral equipment.

POWER MEASUREMENTS. Power measurements were conducted with an "Amprobe A.C. Wattmeter Recorder." The Amprobe recorder uses a current transformer that is snapped around one leg of the incoming power line. Displays were all set to equal operating conditions, and power measurements were taken directly from the metering power scale. The table 1 readings show a definite decrease in power requirements for the FDAD displays as opposed to existing ARTS III displays. Taking an average of the power indications results in 720 watts for FDAD and 925 watts for ARTS III. This results in an average power reduction of 22 percent for FDAD versus ARTS III.

TABLE 1. POWER READINGS

	FDAD	ARTS III
#1	690 watts	900 watts
#2	700 watts	1000 watts
#3	710 watts	950 watts
#4	750 watts	850 watts
#6	750 watts	--

BANDWIDTH MEASUREMENTS. The "X" and "Y" deflection amplifier inputs are shown in the upper right of figure 11. A sinusoidal signal of 10 millivolts peak to peak was injected from the frequency generator. The small input signal used is necessary, since the 3.75 megahertz bandwidth being tested is a "small signal" bandwidth. The "large signal" bandwidth of the amplifiers would be much smaller. An oscilloscope probe on the yoke sense resistor test point (feeding back to the preamplifier) monitors the amplifier output signal. The signal frequency is turned up gradually until the amplitude drops off to its half power point indicating the frequency range. This is -3 dB down or 0.708 of the original signals' voltage level. The half voltage level is -6 dB down. Table 2 illustrates these results. Only two deflection amplifiers out of 10 passed the bandwidth parameter measurements that they were designed for. The others ranged from 45 to 75 percent of rated capability. This lower bandwidth range can have a degenerating effect on characters and vectors such as edge rounding and vector spacing.

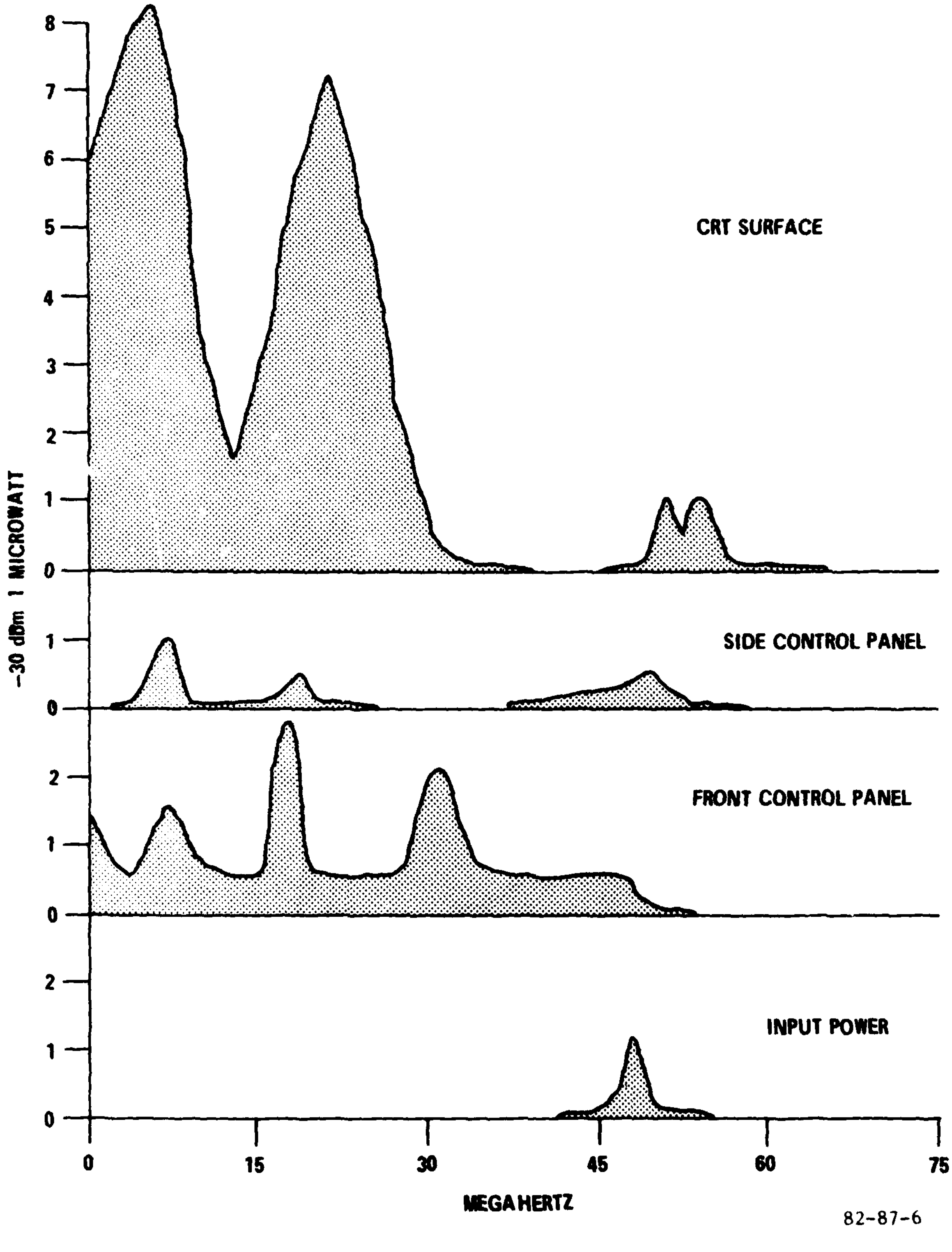

FIGURE 6. RADIO-FREQUENCY INTERFERENCE SPECTRUM FDAD NUMBERS 1 AND 2 - P2/P22B/P28

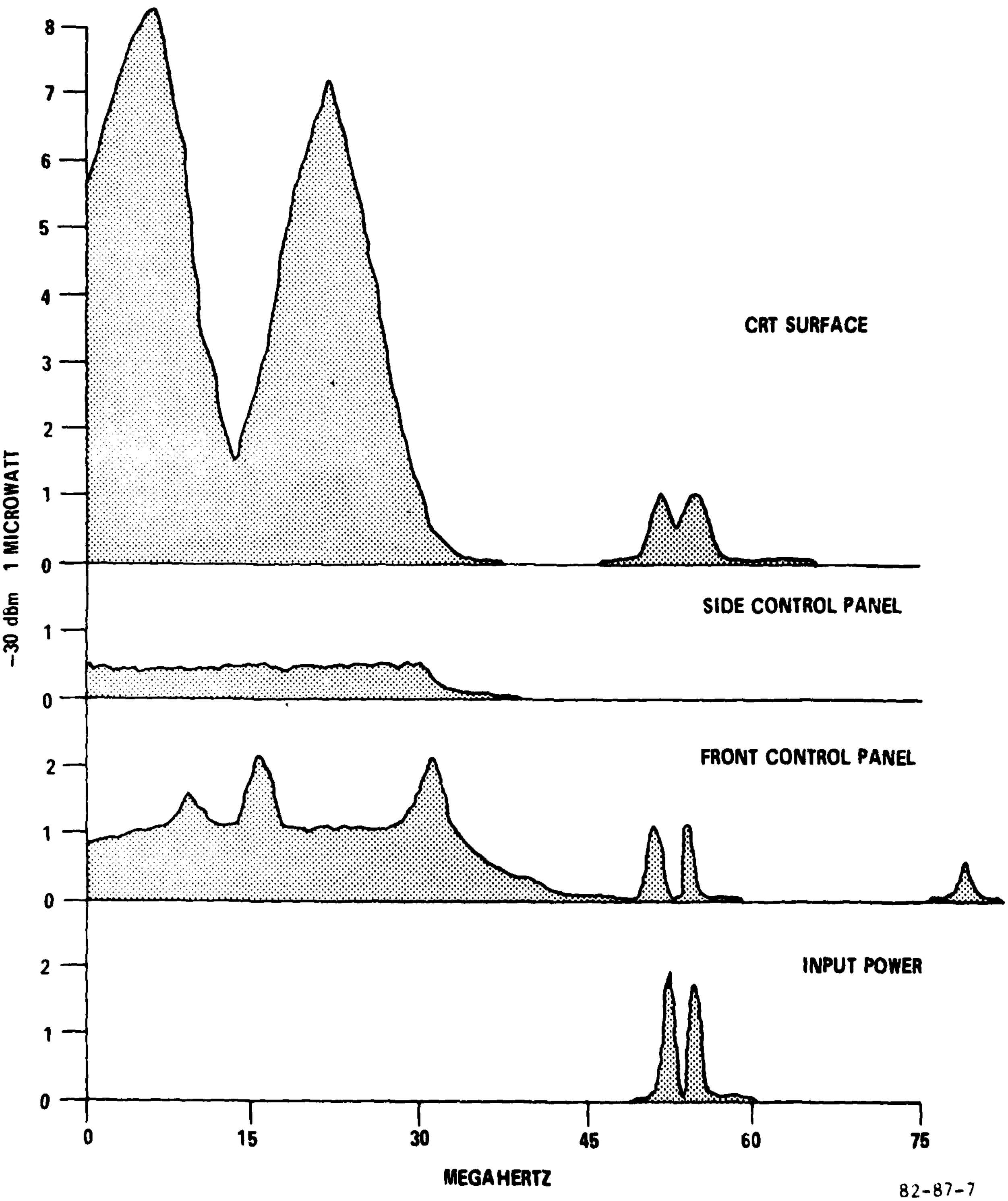

FIGURE 7. RADIO-FREQUENCY INTERFERENCE SPECTRUM FDAD NUMBERS 3 AND 4 - P31

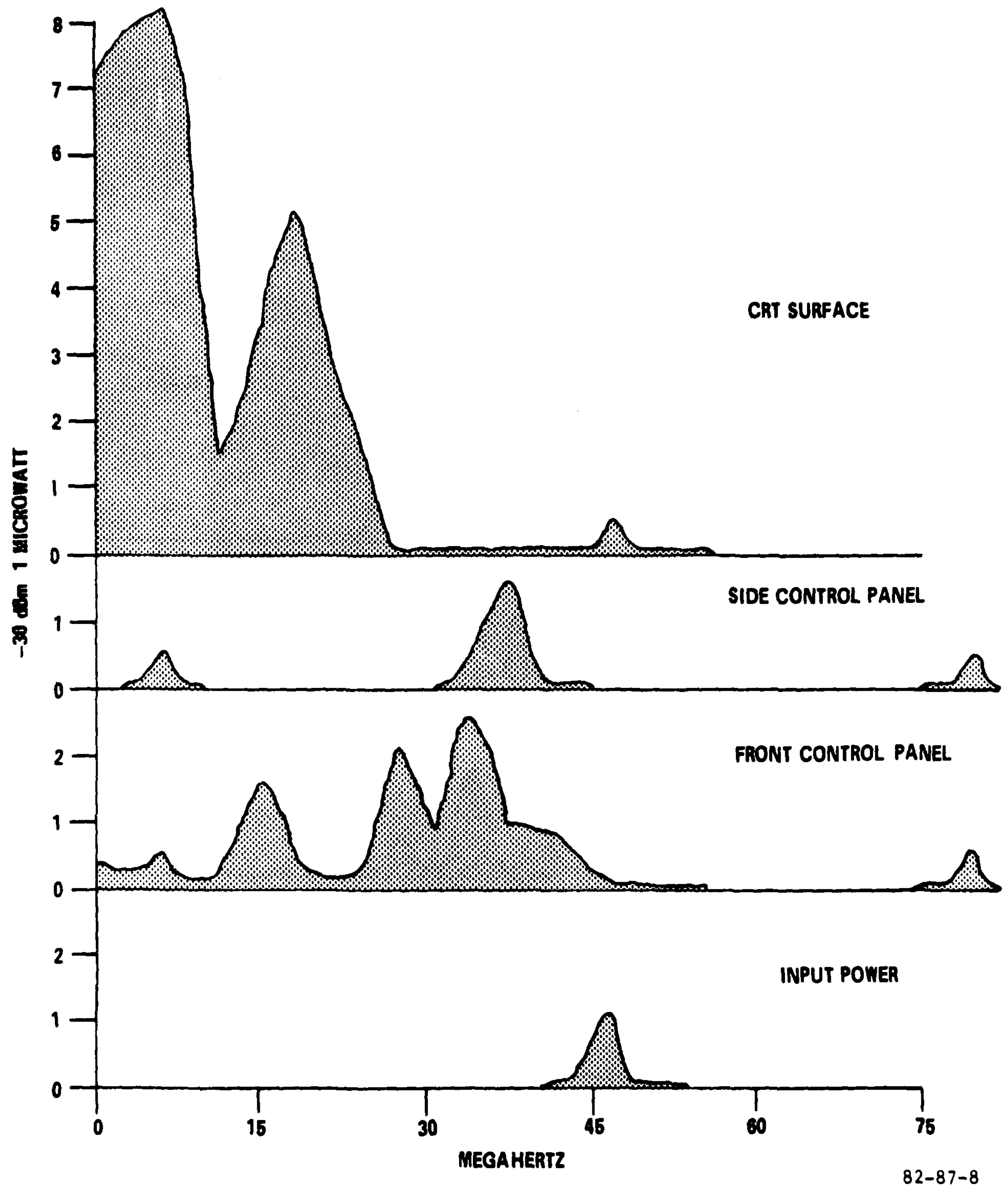

FIGURE 8. RADIO-FREQUENCY INTERFERENCE SPECTRUM FDAD NUMBER 6 - COLOR P49

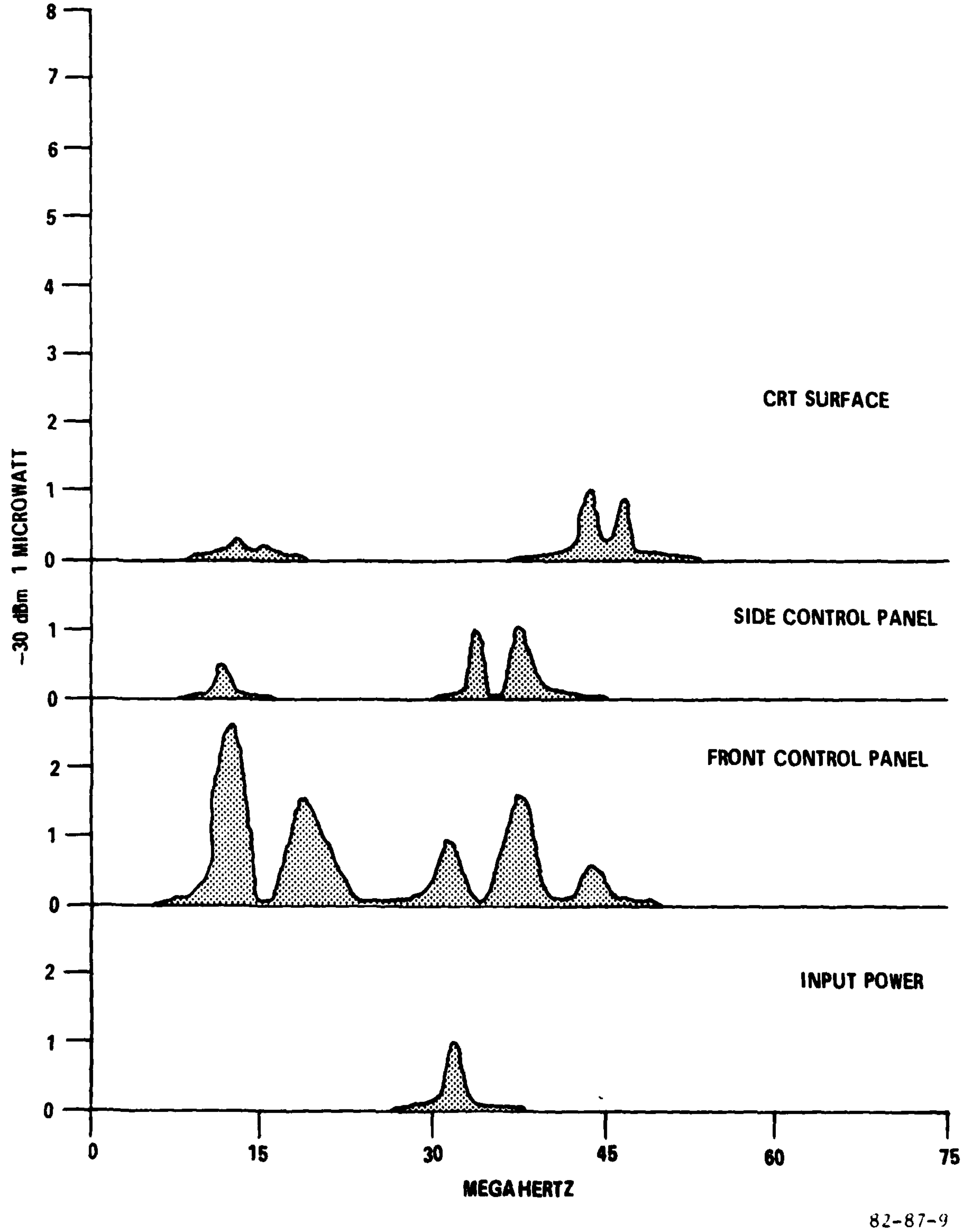

FIGURE 9. RADIO-FREQUENCY INTERFERENCE SPECTRUM ARTS III DISPLAY NUMBER 1

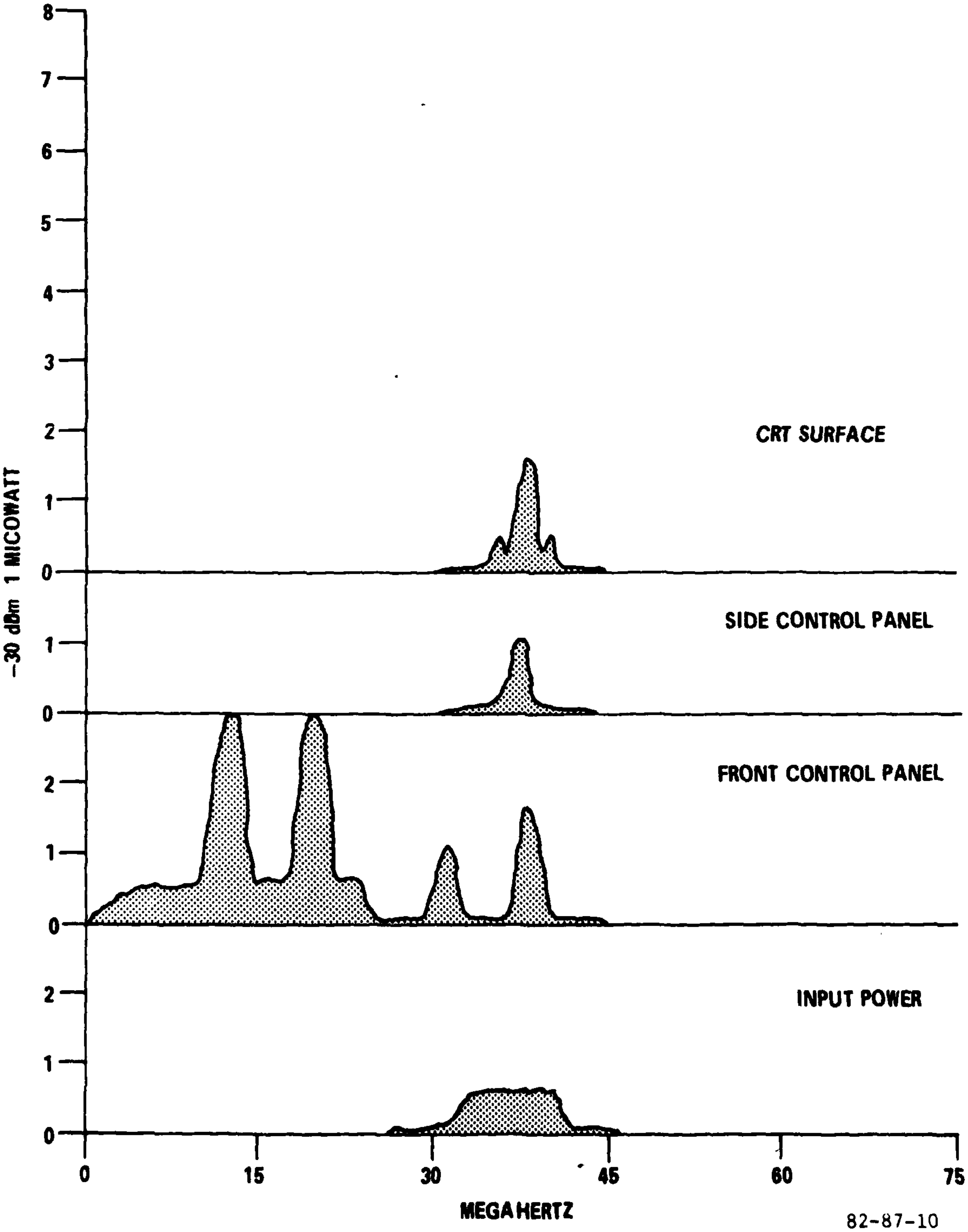

FIGURE 10. RADIO-FREQUENCY INTERFERENCE SPECTRUM ARTS III DISPLAY NUMBER 1

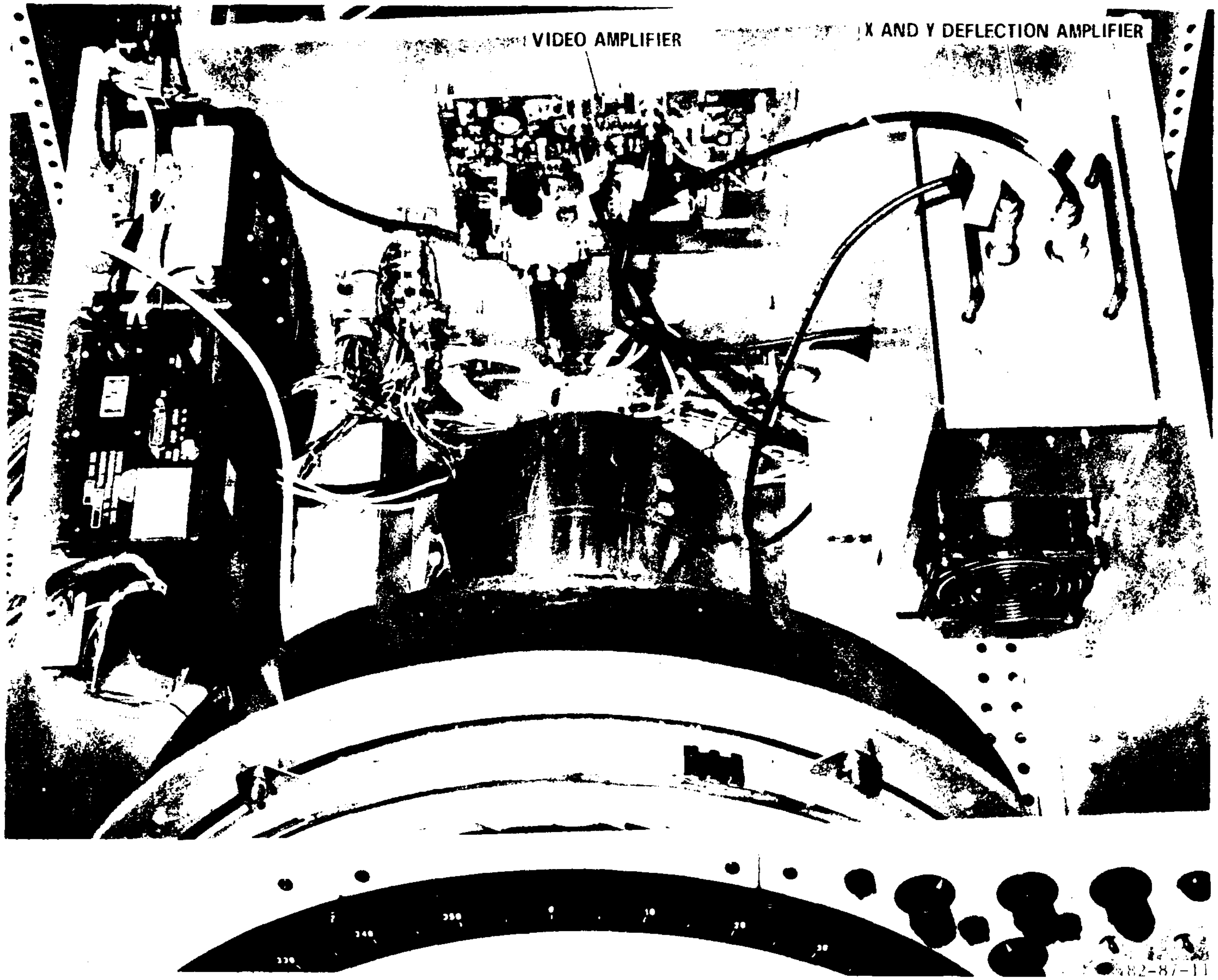

FIGURE 11. AMPLIFIER UNITS

TABLE 2. DEFLECTION AMPLIFIER BANDWIDTH

	1/2 Power Megahertz		1/2 Voltage Megahertz	
	X	Y	X	Y
#1	2.8	3.75	3.3	-
#2	3.75	2.4	-	2.8
#3	2.0	1.7	2.7	2.1
#4	2.0	2.1	2.7	2.6
#6	1.7	1.8	2.6	2.4

The video amplifier input is shown in the upper center of figure 11. A 90-millivolt sinusoidal signal was used for the video bandwidth measurements. The same procedure as in deflection amplifier testing was used, but with an upper range of 20 megahertz. All five video amplifiers were capable of their 20-megahertz bandwidth rating as shown below in table 3.

TABLE 3. VIDEO AMPLIFIER BANDWIDTH

1/2 Power	#1	#2	#3	#4	#6
Megahertz	20	20	20	20	20

System noise in the video and deflection amplifier was investigated and found to be minimum and within acceptable levels. Yoke settling time was not a factor in the viewed display test patterns or computer simulations.

Figure 12 shows the card cage assembly with central processing unit (CPU) boards, memory boards, and other support circuitry. Figure 13 shows the front maintenance status panel and mode selection functions.

FIGURE 12. CARD CAGE ASSEMBLY

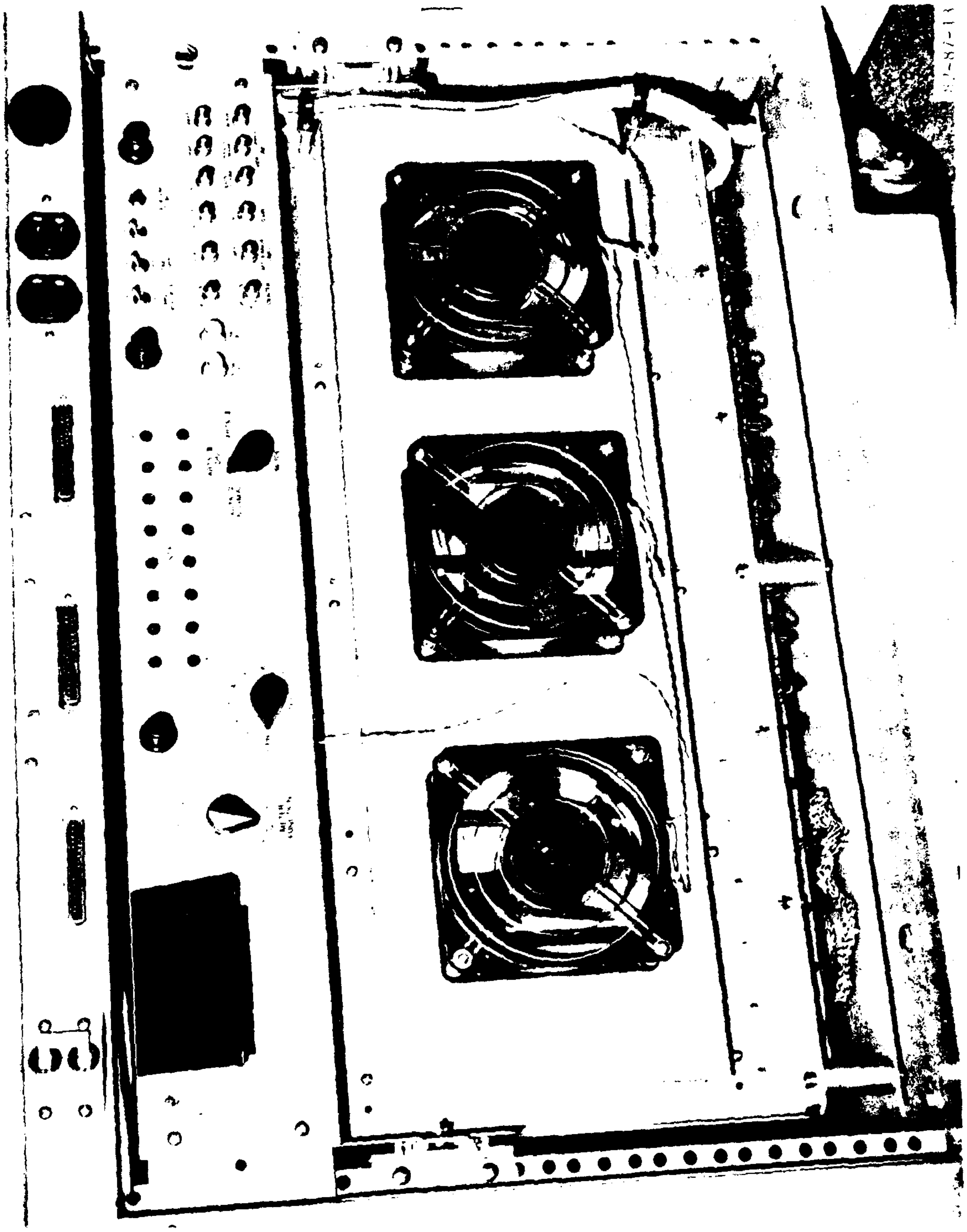

FIGURE 13. MAINTENANCE CONTROL PANEL WITH INDICATORS

CONCLUSIONS

PART 1: OPERATIONAL EVALUATION.

1. Since the use of increased character size to indicate handoff status was found to be unsatisfactory, the current Automated Radar Terminal Systems (ARTS) III method of blinking data should continue to be used.

2. The Full Digital ARTS Display (FDAD), when operated in the digital mode, was not suitable for use in present day automated air traffic control facilities using ARTS computers due to the excessive number of display reinitializations.

3. In order for the display of heavy weather contours and data block leaders to be satisfactory, the present distortion problems must be eliminated.

4. The display controls should be relocated, since their present location below the level of the writing shelf results in erroneous keyboard entries when adjusting the controls.

5. Location of the alphanumeric keyboard and track-ball was satisfactory, but requires improvement since their location precluded the use of the shelf for writing.

6. The digital map and the range circles should have separate intensity controls since most controllers prefer different brightness levels for these functions.

7. The operation of the "TARGET" and "OTHER" digital data brightness controls was unsatisfactory due to the controls being mislabeled.

8. When operating the displays in the time-share mode, unequal range mark intensity at reduced display ranges during clutter breakthrough was not acceptable.

9. When operating the displays in the time-share mode, distortion of range marks when alphanumerics were being displayed was not acceptable.

10. Although the presentation of digital data in four colors was deemed satisfactory, no preference over noncolor displays was indicated.

PART 2: TECHNICAL EVALUATION.

1. The use of modern digital displays like the FDAD units would produce a considerable energy savings due to a 22 percent reduction of power requirement.

2. The greater electromagnetic radiation being produced by the FDAD consoles should not be of any consequence to nearby equipment or personnel. They emit very small signal levels and have a rapid dropoff of radio-frequency interference power with distance (half power every 4 inches).

3. There were three deflection amplifier failures and other deflection problems, indicating a weakness in the deflection circuitry. The lowered signal bandwidth would have a detrimental effect on the quality of vectors and alphanumerics being generated on the cathode-ray tube surface.

4. The video amplifier bandwidth meets or surpasses the rated performance capability of 20 megahertz.

5. Many of the maintenance problems encountered could have been avoided if it were not for the fragility of the board wire-wrap pins and connectors.

6. The longevity of the low voltage and high voltage switching power supplies is inadequate for long-term FDAD operation.

7. Due to past experience with Venus high voltage switching power supplies and present failures during operation, the choice of this design is unsatisfactory.

8. FDAD users have noticed problems with the range mark generating circuitry. A noticeably brighter area appears over the ground while in time-share mode with moving target indicator (MTI) circuit off and increased background gain. This is more evident during reduced radar range. This results from a problem with the original specifications but is less noticeable in ARTS III displays. Another problem of serrated range marks can be observed during ARTS III normal operation with time-share mode and time compressor turned on. The problem is fixed when the time compressor is turned off. It is believed that this problem occurred because the FDAD is unable to locate the positioning of the sweep origin.

RECOMMENDATIONS

PART 1: OPERATIONAL EVALUATION.

To make the Full Digital Automatic Radar Terminal Systems (ARTS) Display (FDAD) operationally suitable, it is recommended that the following modifications to software, hardware, or firmware be accomplished.

1. Utilize blinking alphanumeric data in lieu of increased character size during handoff situation.

2. Isolate the cause and eliminate the excessive FDAD reinitializations and alphanumeric flicker.

3. Eliminate distortion of data block leaders and lines forming the heavy weather contours.

4. Move the display controls located below the level of the writing shelf to locations above the shelf.

5. Reconfigure the writing shelf identically to the writing shelf on the Texas Instruments ARTS III display's writing shelf.

6. Provide separate display controls for digital map and range circle brightness.

7. Relabel the "TARGET" and "OTHER" digital data brightness controls.

8. When operating the displays in the time-share mode, eliminate unequal range marks intensity during clutter breakthrough at reduced display ranges.

9. When operating the displays in the time-share mode, eliminate distortion of range marks when alphanumerics are being displayed.

PART 2: TECHNICAL EVALUATION.

With any new engineering model displays of FDAD complexity, there will always be problems and breakdowns of certain components. Preproduction models are used to work out these discrepancies and to develop specifications for field quality displays. Maintenance records indicate that modifications were introduced during the week of November 14, 1981 (appendix A), with the intent of straightening out some discrepancies. The following should be investigated for further FDAD improvement:

1. Deflection amplifier design/quality control for bandwidth improvement and uniformity.

2. Wire-wrap boards need a protective guard to prevent easy breakage of wire-wrap pins.

3. Production quality boards should not have any wire-wrapped connections or the present type edge connectors.

4. Low-voltage power supply needs current limiting circuitry to reduce shorting failures.

5. High-voltage switching power supply operation should be scrutinized for greater reliability.

6. Investigate range mark generating circuitry for reducing ground clutter brightening and range ring serration.

7. Further use of FDAD units with contractor modifications for production of a usable prototype display.

APPENDIX A

SUMMARY OF MAINTENANCE LOGS

The following is a summary of the maintenance logs after FDAD's were turned over to the FAA on July 24, 1981:

8-14-81	-	Range rings on color display will not appear in the all digital mode unless powered down or reset first.
9-3-81	-	FDAD #2 - 1A1A2 horizontal deflection amplifier board failed and was replaced.
10-5-81	-	FDAD #1 - Over temperature problem caused by "X" deflection amplifier being over driven. This is only noticed during ARTS III mode operation. Signals are being gated through without unblanking. System reset not working correctly.
10-6-81	-	FDAD #1 - 1A2A31 pin 100 broken off. FDAD #3 - 1A2A31 board and pin 100 not good FDAD #1 Fixed, FDAD #3 - 1A2A31 board replaced. Wire-wrap pins easily broken or bent, thus causing other problems when they short.
10-7-81	-	FDAD #4 - Sweep braking up, especially on 40-mile range. "X" deflection amplifier adjustment out of tolerance. Problem when switching between time compressed and noncompressed. Alphanumerics blink when not in time compressed.
10-14-81	-	FDAD #6 - Focus at center normal, data at outer edge out of focus. FDAD #1 - During precipitation, streaking is visible on the side of the weather that is away from the main bearing antenna. FDAD #2 - Range mark intensity is too high in areas of weather and the sweep intensity is not uniform.
10-23-81	-	FDAD #1 - Low-voltage power supply failed and replaced.
10-26-81	-	FDAD #1 - Analog radar intermittent, replaced board 1A2A31 (cracked connector near pins 95-100).
10-27-81	-	FDAD #1 - Shadowing and ghosting of heavy weather areas on analog radar board (replaced board 1A2A30).
10-28-81	-	FDAD #6 - Characters smeared in "Y" direction in test pattern #2 (replaced "Y" deflection amplifier). FDAD #4 - Deflection amplifier defective, possibly a failed power transitor (replaced deflection amplifier).

10-29-81 - Capacitors added to improve the control of vectors by noise reduction. Also, they reduce the noise of integrated circuit adders for better stability of weather vector starting points. Range mark pulse widths were widened to improve the range mark quality in time compressed operation. FDAD #1 has many bent and broken wire-wrap pins.

10-30-81 - FDAD #1 - Low-voltage power supply failing as on 10-23-81. Replaced after checking all bent or broken wire-wrap pins.

11-10-81 - FDAD #6 - High-voltage switching power supply replaced.

11-14-81 to 11-18-81 - Entry by Magnavox personnel:

1. Added extra heat sinks to all deflection amplifiers.
2. Modified all deflection correction boards (A38) to correct dynamic focus output signal.
3. Readjusted dynamic focus on all systems for better edge focus.
4. Tested and repaired the beam in motion circuit on the deflection amplifiers for all units.
5. Modified video time compressor to eliminate ghosting in heavy weather conditions.
6. Replaced four capacitors in the low voltage power supply with higher voltage rating ones in all systems and spare.
7. Replaced the card nest cabinet locks on all systems.
8. Readjusted the fifth range mark intensity on all units except for the color unit (FDAD #6).
9. The following boards had failed and were taken back for evaluation:
   a. Deflection amplifier SN2.
   b. Time compressor SN008.
   c. Time share control SN003.
   d. Data entry control panel SN006 and SN007.
   e. CPU SN011 and SN003 failed in A1 card slot of FDAD #4.

12-1-81 - Problem with FDAD #2 while running Multiplex Display Buffer Memory (MDBM) Data Entry Display Subsystem (DEDS) Program Operational Functional Appraisal (POFA) from systems 1 and 3. POFA would not come up on FDAD #2 while in the time-share mode, but worked normally in digital mode.

12-4-82 - Swapped 1A2A7 board between FDAD #1 and FDAD #2. Problem followed in that FDAD #1 will not initialize in the time-share mode.

APPENDIX B

SUMMARY OF CONTROLLER RESPONSES TO FDAD QUESTIONNAIRES

In this Questionnaire Summary, if a comment was received to a particular question, it is indicated by an "X" in the Comments column. Comments are listed on pages B-6 through B-10. Bracketed number following each comment indicates the number of times the comment was made.

	SATISFACTORY	UNSATISFACTORY	COMMENTS
1. Spare Video	96%	4%	
2. Compass Rose Illumination	96%	4%	
3. Panel Illumination	100%	0%	
4. CRT Focus	77%	23%	X
5. Time Share/Digital Switch	100%	0%	
6. Field Inhibit Switches	88%	12%	X
7. MTI/Normal Gate ON/OFF	96%	4%	X
8. MTI/Normal Gate Adjust	88%	12%	X
9. Sweep Intensity	88%	12%	X
10. Center/Decenter	80%	20%	X
11. Decenter West/East	77%	23%	X
12. Decenter South/North	77%	23%	X
13. MTI/Normal	92%	8%	X
14. Background	92%	8%	X
15. Beacon	80%	20%	X
16. Radar Range	92%	8%	

	SATISFACTORY	UNSATISFACTORY	COMMENTS
17. Map (Time-share Mode)	80%	20%	X
DIGITAL DATA BRIGHTNESS (Digital Mode)			
18. Target	77%	23%	X
19. Weather	85%	15%	X
20. MAP/Circles	65%	35%	X
21. Other	77%	23%	X
22. Quick Look Switches	80%	20%	X
23. Map Select (Digital Mode)	73%	27%	X
24. Range Mark Intensity (Time-Share Mode)	65%	35%	X
25. Range Mark (Selector)	73%	27%	X
26. Character Size	69%	31%	X
27. Leader Direction	65%	35%	X
28. Leader Length	85%	15%	X
29. The displayed data when operating the display in the time-shared display mode was	77%	23%	X
30. The location of the A/N keyboard was	50%	50%	X
31. The location of the track-ball was	61%	39%	X

	SATISFACTORY	UNSATISFACTORY	COMMENTS
32. The track-ball operation at reduced display ranges was	69%	31%	X
33. The location of the shelf on the console was	69%	31%	X
34. The increased character size in lieu of a data blinking during a handoff situation was	31%	69%	X
35. When operating in the time-shared display mode, the displayed radar data on the CRT with the phosphor mixture was	73%	27%	X
36. When operating in the digital display mode, the displayed data on the CRT with the phosphor mixture was	85%	15%	X
37. When operating in the time-shared display mode, the displayed radar data on the CRT with the P31 phosphor was	31%	69%	X
38. When operating in the digital display mode, the displayed data on the CRT with the P31 phosphor was	100%	0%	
39. The display of digital data was	100%	0%	
40. The controls (Digital Data Brightness) for color were	85%	15%	X
41. The color used to display weather was	85%	15%	X
42. The color used to display the Digital Map and Range Rings was	65%	35%	X

	SATISFACTORY	UNSATISFACTORY	COMMENTS
43. The color used to display lists, full data blocks, and altitude data blocks was	96%	4%	
44. The color used to display history trails and reported position of unassociated single symbols was	96%	4%	
45. The brightness level of RED was	85%	15%	X
46. The brightness level of YELLOW was	92%	8%	
47. The brightness level of GREEN was	92%	8%	
48. The brightness level of ORANGE was	88%	12%	X

	YES	NO	COMMENTS
49. When operating in the digital display mode, did you notice any interaction between any of the Digital Data Brightness control	4%	96%	X
50. Was fatigue encountered during observation of the color display	15%	85%	X
51. Was the location of the operating controls unsatisfactory? If yes, list the controls	23%	77%	X
52. Are there any additional features that you would desire incorporated into the display? If yes, please list them	23%	77%	X
53. In your opinion, were there any controls not provided on the display that you would desire	27%	73%	X

Question #	Comments
4.	Too sensitive.(1) Not focused at edge when focused a center. (5)
6.	Not needed.(1)
7.	Not noticeable on P31.(1)
8.	Not noticeable on P31. (1) Increased intensity at end of MTI. (1)
9.	Not noticeable on P31. (2) Blue sweep is objectionable. (1)
10.	Display distorted when moved.(1)
11.	Not push to turn.(2)
12.	Not push to turn.(2)
13.	Not noticeable on P31.(1)
14.	Not noticeable on P31.(1)

Question #	Comments
15.	Not distinguishable and too fat.(1) Beacon fades too quickly. (1)
17.	Fuzzy, fades too quickly.(1)
18.	Mislabled. (5)
19.	Do not like how weather is displayed. (3)
20.	Map and range should be on separate controls. (8) Fades too quickly. (1)
21.	Mislabled. (7) State function of switch.(1)
22.	Relocate. (3) Prefer push button.(1)
23.	Switch position is no good. (6) Hard to select on color.(1)
24.	Range mark intensity too delicate to adjust. (1) Switch position no good.(5) Range mark loss when precipitation or ground clutter crosses. (1) Cluster digital separate from time-share.(1)

Question #	Comments
25.	Switch position is no good. (6)
26.	Character size should be smaller. (1)
	Switch position is no good. (5)
27.	Switch position is no good. (5) Put entire function
	under keyboard control. (1)
28.	Do not need leader length 6 thru 8. (1)
	Switch position is no good. (5)
29.	Beacon returns bad. (3) Grainy, fuzzy, low persistence. (2)
30.	Keyboard should be relocated from under arm. (12)
	More shelf space needed. (2)
31.	Relocate. (12)
32.	Too fast. (4) Relocate. (4) Make bigger. (2)
33.	Shelf cluttered. (1) Need more space for strips. (2)
	Shelf lower and closer to display. (6) Uncomfortable. (1)

Question #	Comments
34.	Blinking preferred. (14) Not noticeable. (3)
35.	No retention. (3) Do not like constrasting sweep. (2)
36.	No retension.(1) Bad on eyes. (2) Time-share trail annoying. (1)
37.	Weak and washed out. (2) Insufficient retension. (9)
40.	Map and range marks should be separate controls. (4) Better calibration needed. (1)
41.	Appears confusing. (2) Color looks same as #42. (1)
42.	Should be separate control for MAP and range marks. (5) Caused eye fatigue. (2) Color looks same as 41. (1)
45.	Red and Orange too similar. (1) Better calibration.(1)
48.	Red and Orange too similar. (1) Orange distorted. (1)
49.	Map and range mark should be on same knob. (3) Target control adjusts A/Ns and OTHER control adjusts targets. (1)

Question #	Comments
50.	Not sufficient time for fatigue test. (1) Eyes watered after 20 minutes(1) Color easy on eyes. (1) Eye fatigue encountered. (2)
51.	Map select - Range mark intensity - Character size - Leader direction and length (7) - Quick look (2) - All unsatisfactory (1) - Keyboard and slew ball (1) Separate digital controls from normal controls. (1)
52.	Map and range marks separate control. (3) Use different colors. (1) Separate weather controls for high and low weather. (1) Ash tray, pencil tray.(1) More leg room. (1)
53.	Separate map and range mark controls. (4) Better means of offset control. (1)

DATE

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